Initial State Dependence of J/Ψ and Drell-Yan Yields in Nucleus-Nucleus Collisions

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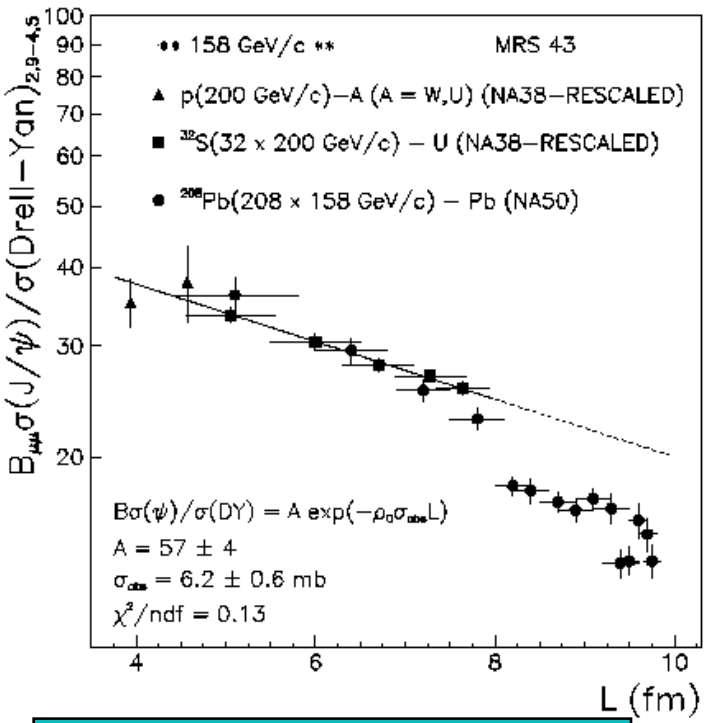
"Anomalous" J/Ψ Suppression

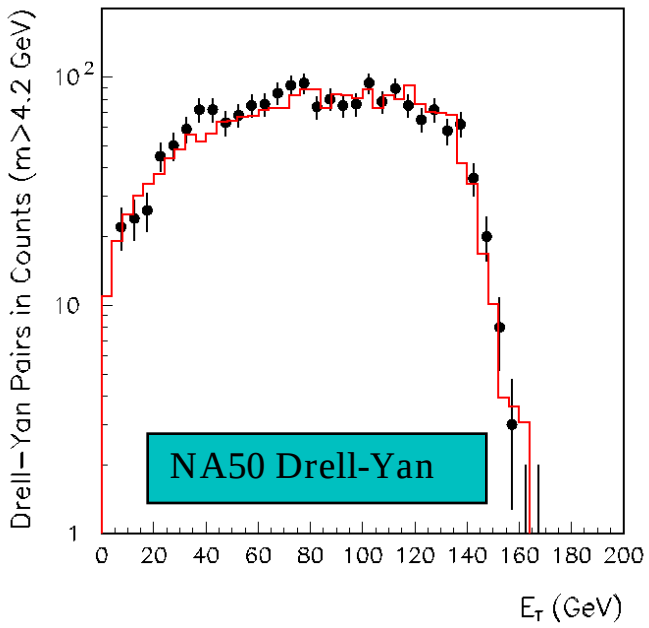
NA38, NA50 J/Ψ to DY ratio

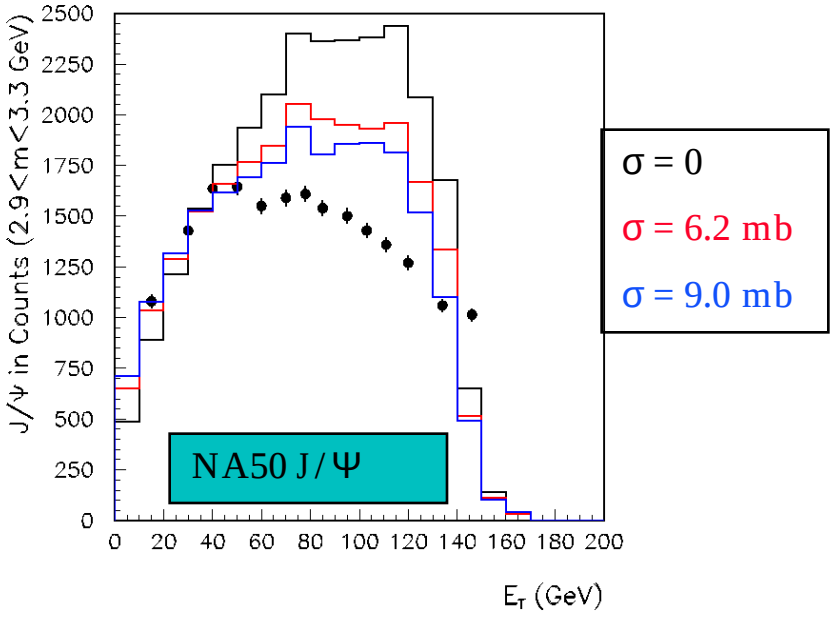


L. Ramello, Quark Matter '97

- Yields from p-A and A-A (through S) described by absorption cross section of 6-8 mb--consistent with predictions for c-cbar-g color octet state
- Yields from Pb-Pb collisions display absorption beyond this level, so-called "anomalous suppression"
- QGP?? or conventional explanation? e.g. comover absorption, energy loss
- Need to look at J/Ψ, DY individually, as a function of centrality

Comparison to Simple Glauber

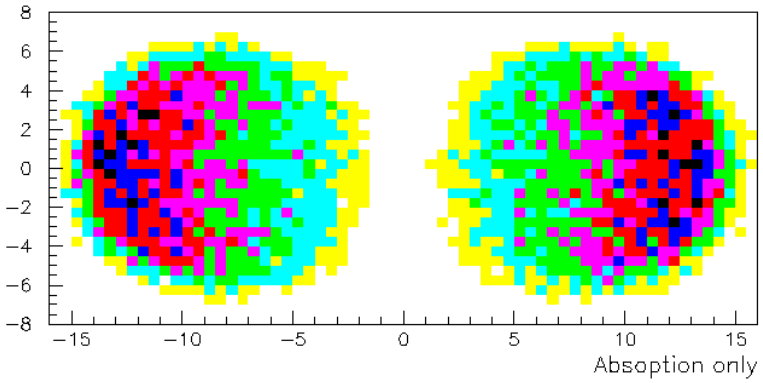


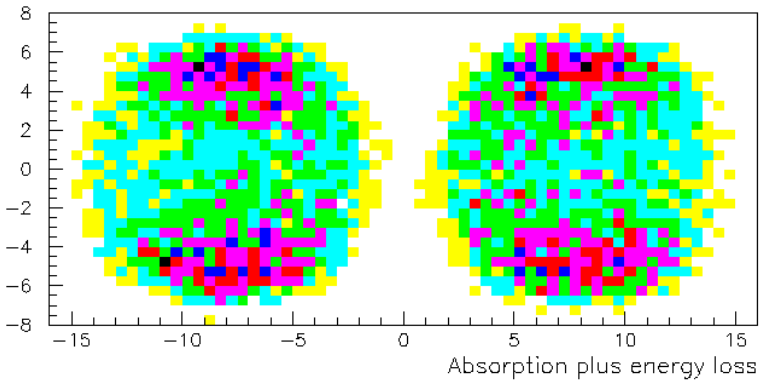


- Simple Glauber model, with production from all N-N collisions equally likely
- E_T = constant * Wounded nucleons, smeared by 94% /√E resolution
- Drell-Yan yields are fit very well
- J/Ψ yields are not fit well with absorption cross sections from 6-9 mb

Geometry of Energy Loss

Absorption only

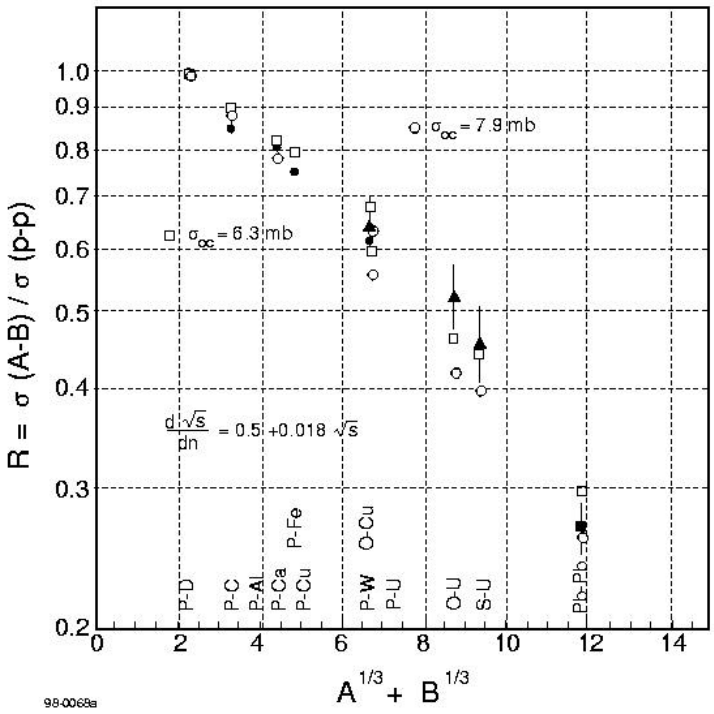




Absorption + Energy Loss

- Nucleons lose energy as they traverse the colliding nucleus
- Production of J/Ψ and Drell-Yan have steep energy dependence
- Affects J/Ψ and DY differently
- Reduces total yield
- Reduces Cronin effect, changes p_t spectrum
- Mimics QGP signal

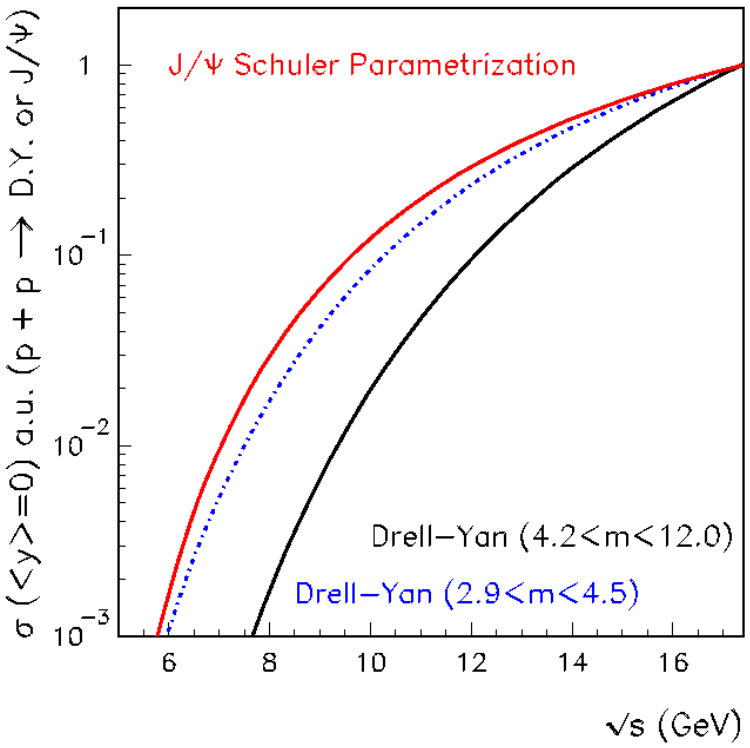
Energy Loss in Min Bias Collisions



Frankel & Frati, hep-ph/9710532

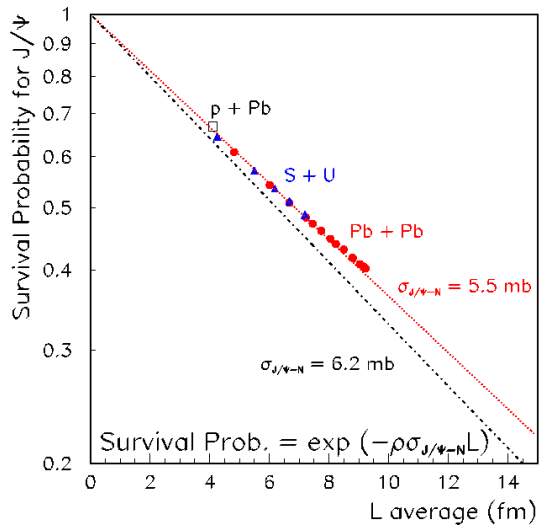
- J/Ψ yield per N-N Collision, plotted against Mean Number of N-N Collisions
- Absorption only gives simple exponential
- Energy loss suppresses from simple exponential
- Want to look at detailed centrality dependence, for both J/Ψ and Drell-Yan

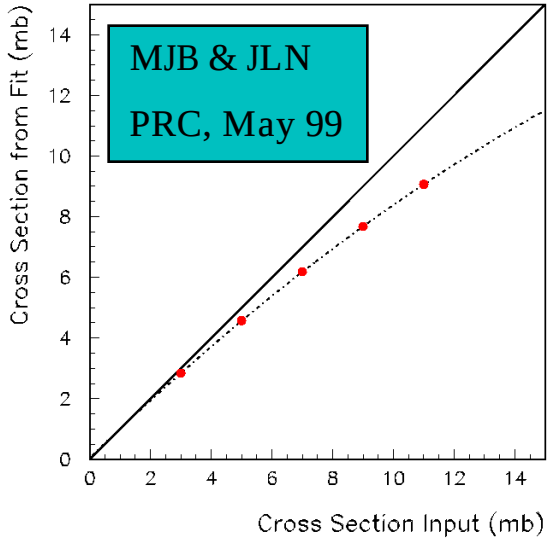
The Model and Parameters



- Glauber Formalism, using 30mb N-N cross section
- Disregarding energy loss, all N-N Collisions contribute equally
- J/Ψ produced “at rest”, absorption cross section 7.1 mb
- Nucleons lose a fraction of momentum in each collision
- Energy dependent production of J/Ψ and DY

The “L Parameter” and Absorption Fits



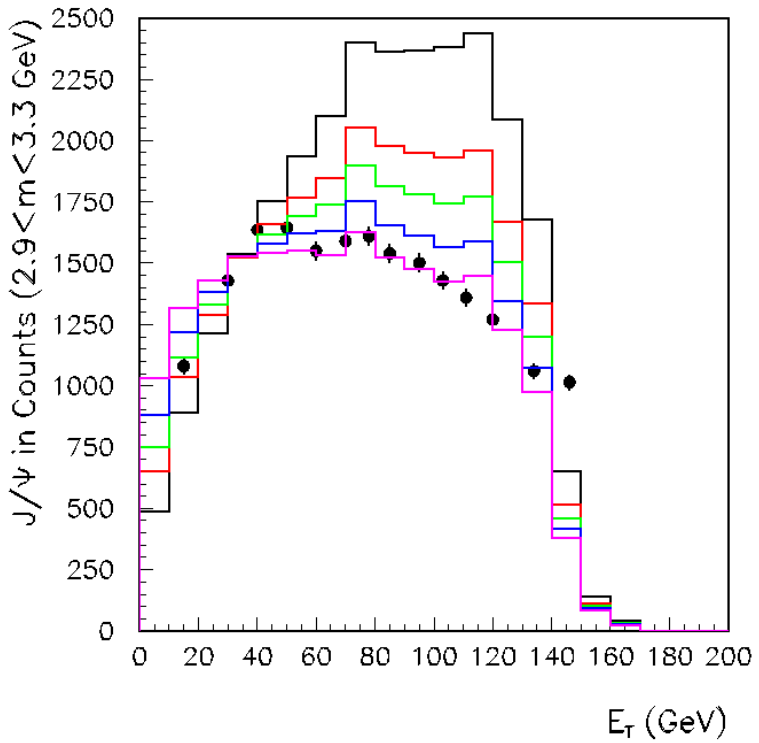


- At fixed impact parameter, J/Ψ path lengths vary widely; each centrality bin represents a variety of impact parameters
- A simple average over path lengths underestimates absorption cross section; using an iterative process, a refit gives 7.1 ± 0.6 mb
- Consistent with an fit with different methodology (7.3 ± 0.6 mb, Kharzeev et al, ZPC74, 307 (1997)

Time Scales for Energy Loss

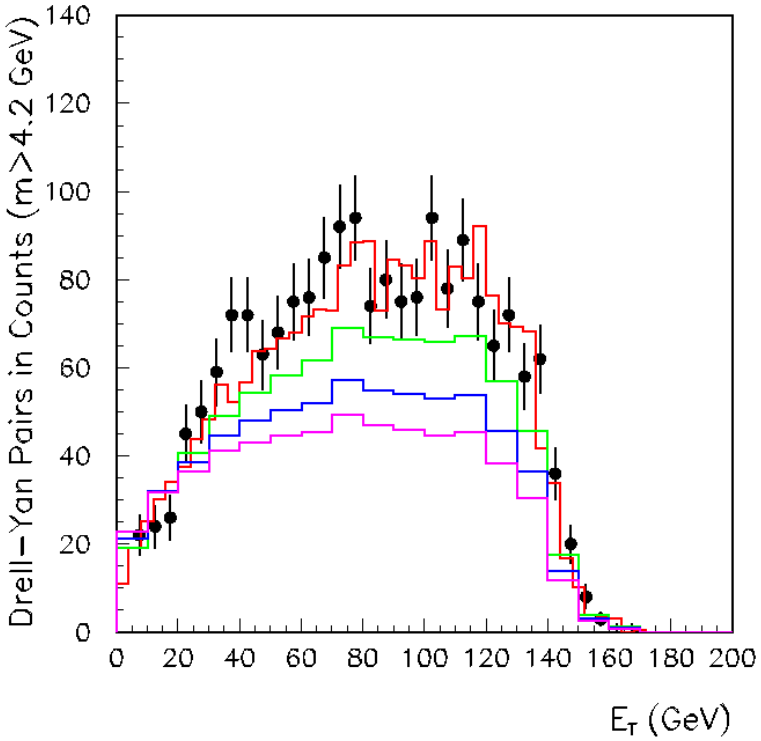
- At CERN energies, nuclei cross in ~0.1 fm/c
- Most energy loss is via soft interactions, with a time scale of a few fm/c
- Stopping in p-A collisions suggest nucleons lose ~40% of their momentum per collision at $t=\infty$
- Some fraction of this energy loss is at short time scale, treat as a variable parameter

J/Ψ Yields with Energy Loss



- Several values of Energy Loss 0%, 5%, 10% and 15% momentum per collision (0%, 10%, 20%, 30% of total t=∞ loss)
- Normalization chosen to give best fit in lowest two E_T bins
- Highest Energy Loss matches spectral shape well

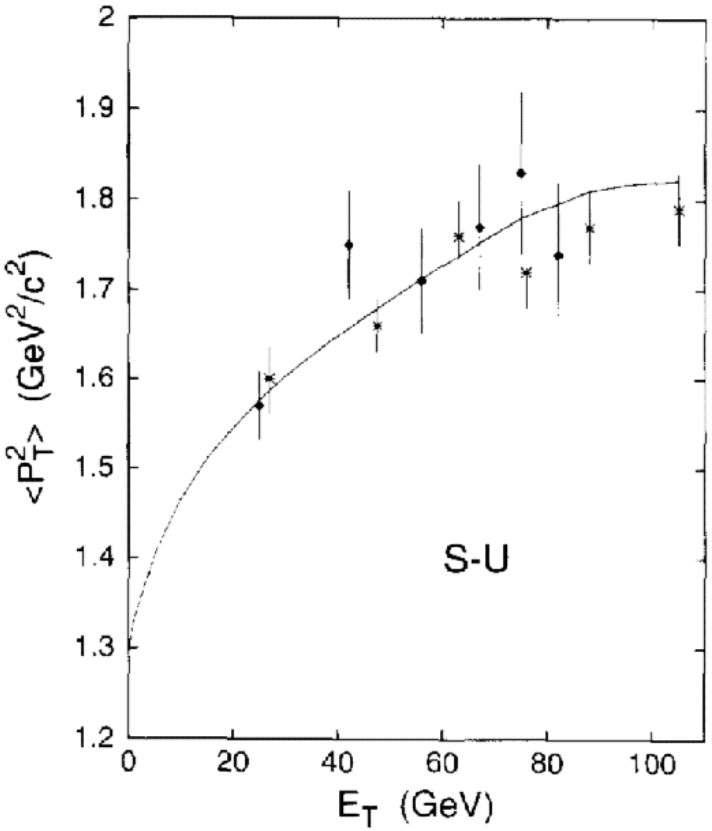
Drell-Yan Yields with Energy Loss



- Several values of Energy Loss 0%, 5%, 10% and 15% momentum per collision
- Normalization chosen to give best fit in lowest E_T bins
- Hard to reconcile any energy loss with data
- Is it reasonable to assume same energy loss is applicable for both J/Ψ and DY?

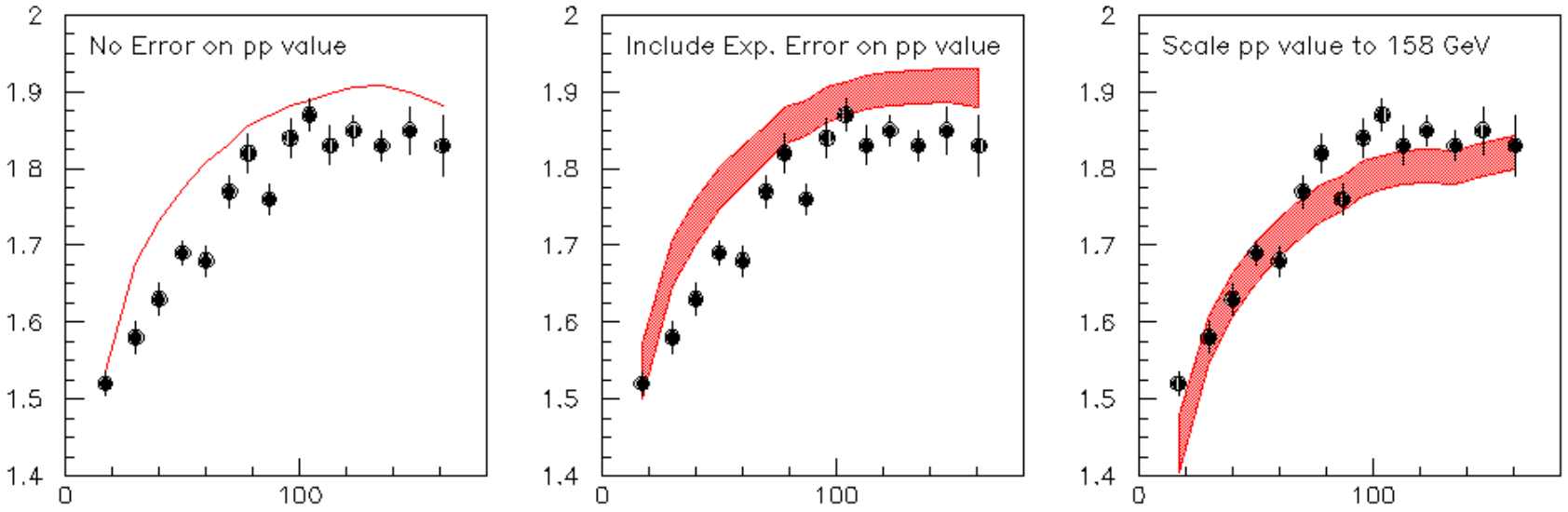
Cronin Effect

$$\langle p_t^2 \rangle_N = \langle p_t^2 \rangle_{pp} + N \ \Delta p_t^2$$



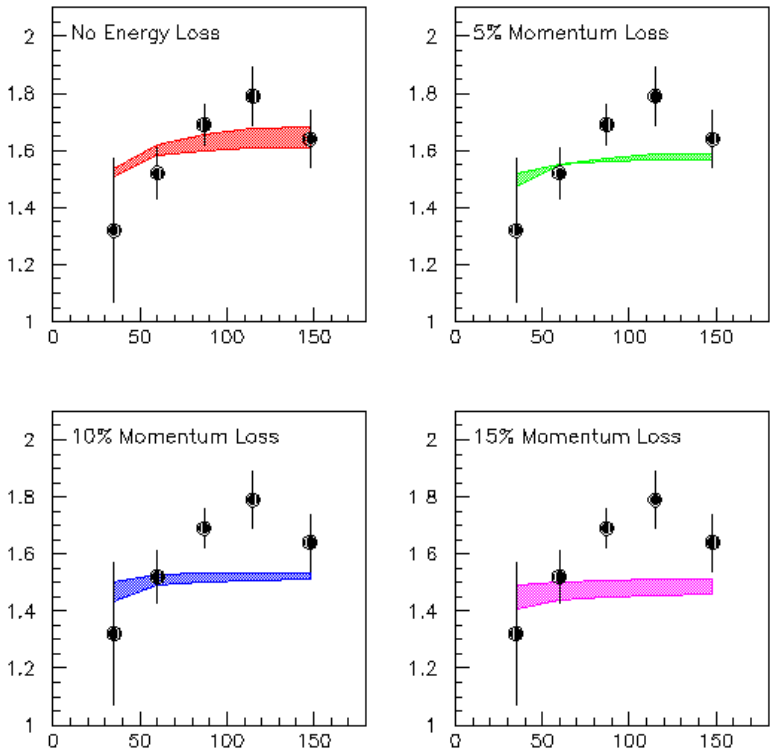
- Prior N-N Collisions broaden transverse momentum ("Cronin effect")
- J/Ψ: $\langle p_t^2 \rangle_{pp} = 1.23 \pm 0.05$ GeV^2 (NA3);
  $\Delta p_t^2 = 0.125$ GeV^2 (fit to pA + AA, Kharzeev et al, PLB 405, 14 (1997))
- DY: $\langle p_t^2 \rangle_{pp} = 1.38 \pm 0.07$ GeV^2 (NA3);
  $\Delta p_t^2 = 0.056$ GeV^2 (fit to pA + AA, Gavin and Gyulassy, PLB 214, 241 (1988))

Is QGP necessary to fit J/Ψ $<p_t^2>$?



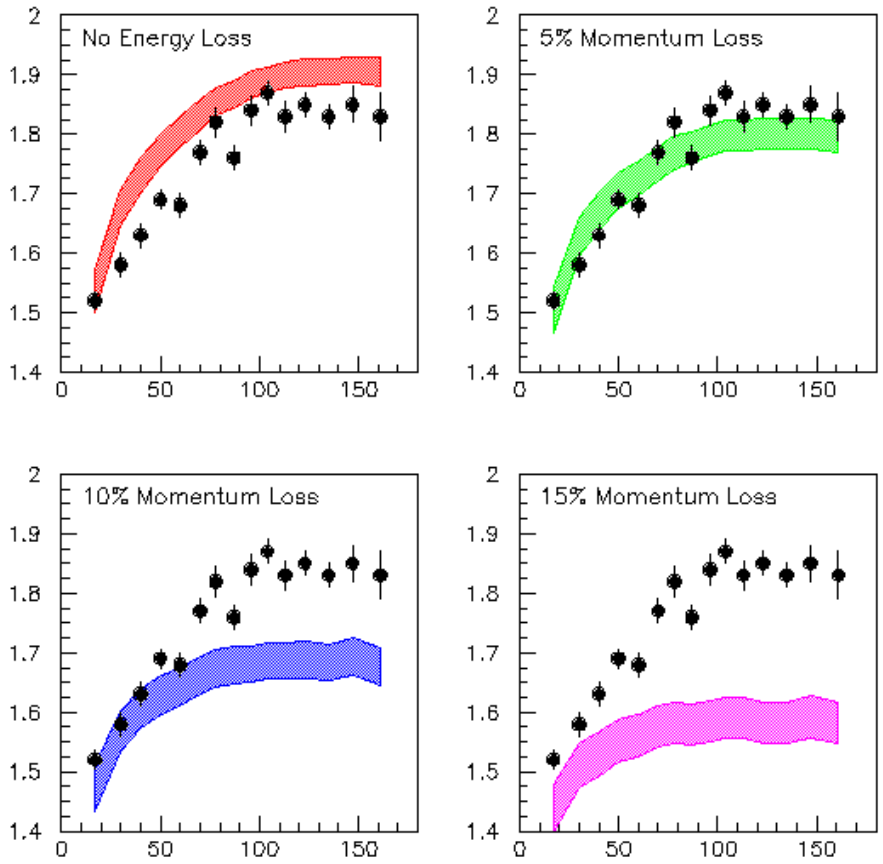
- Must take error in pp data into account
- pp data taken at 200 GeV; scaling to 158 GeV (linear in s) reduces pp "intercept" to 1.13 GeV^2--changes normalization, not shape
- Fermi momentum?---some uncertainty in normalization

Drell-Yan $<p_t^2>$ with Energy Loss



- Several values of Energy Loss 0%, 5%, 10% and 15% momentum per collision
- Spectra not very sensitive to energy loss

J/Ψ $<p_t^2>$ with Energy Loss



- Several values of Energy Loss 0%, 5%, 10% and 15% momentum per collision
- Large values of Energy Loss do not fit data
- Not consistent with Energy Loss required to fit J/Ψ yields

Conclusions

- Fits using a linearly averaged “L parameter” underestimate the absorption cross section
- Given normalization uncertainty, J/Ψ $<p_t^2>$ spectrum does not definitively rule out normal hadronic scenario
- Adding Energy Loss can fit the J/Ψ yield shape ...BUT
- Energy Loss cannot consistently fit both J/Ψ and Drell-Yan yields
- Energy Loss cannot consistently fit both J/Ψ yields and J/Ψ $<p_t^2>$ spectra
- Energy Loss does not appear to explain “anomalous” J/Ψ suppression